Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

HPC and data requirements for weather, climate and air quality research

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Centro Nacional de Supercomputación

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What

Environmental modelling and forecasting

Why

Our strength …
- … research …
- … operations …
- … services …
- … high resolution …

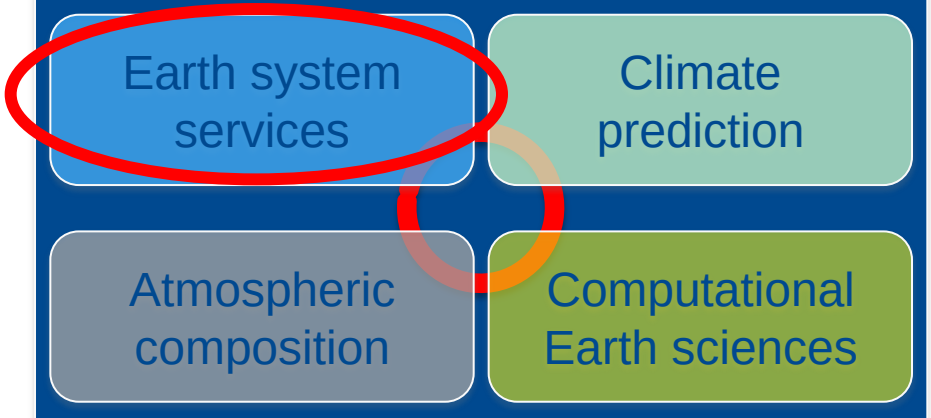
How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models



Air quality operational forecasts

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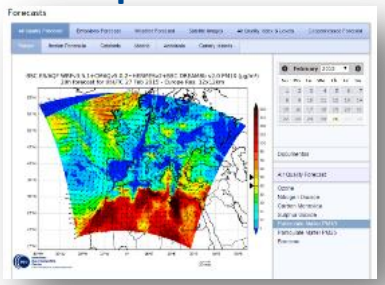
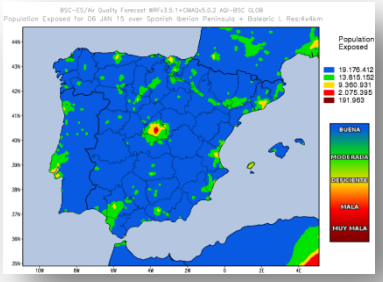
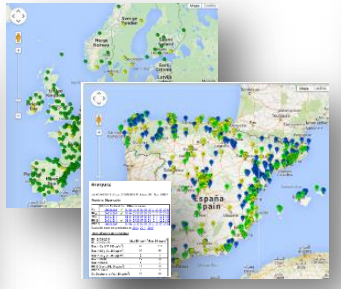
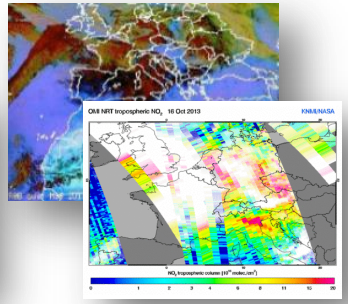
AQF CALIOPE system: daily forecast and evaluation

Daily forecast for **meteorology, emissions and air quality**: Europe (12km), Iberian Peninsula (4km), Andalusia, Catalonia and Madrid (1km), since 2007

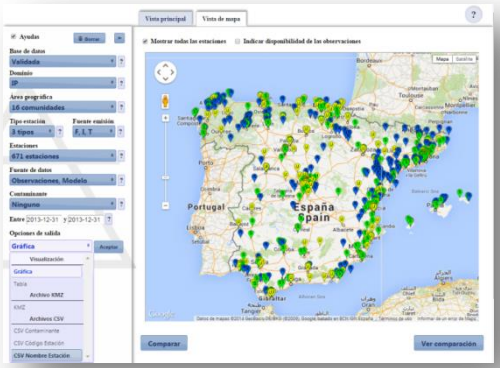
Forecast products

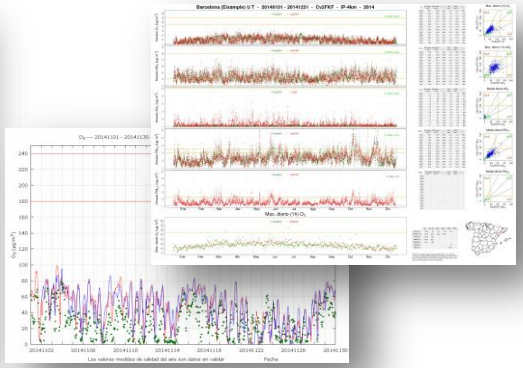




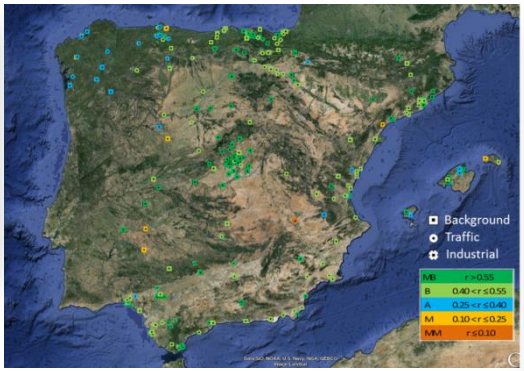
Air quality database

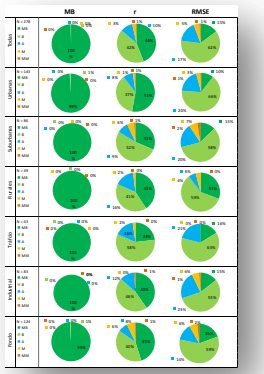


Near Real Time evaluation

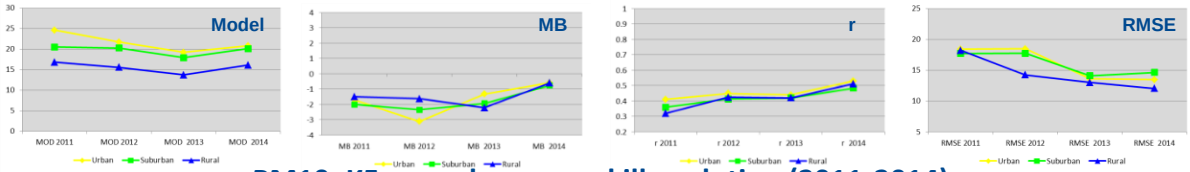


Annual evaluation by air quality stations



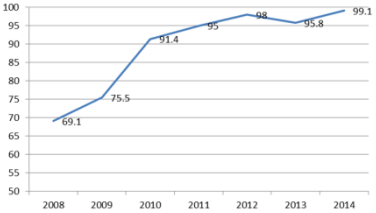


Annual follow up



PM10_KF annual average skill evolution (2011-2014)

Rate of successfully completed simulations (%)



Air quality operational forecasts

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VODAFONE

Ciudad conectada

Vodafone.es/ciudad-conectada

CALIOPE

Provides air quality forecasts for Vodafone's smart cities system

MYGEOSS
APPS FOR YOUR ENVIRONMENT

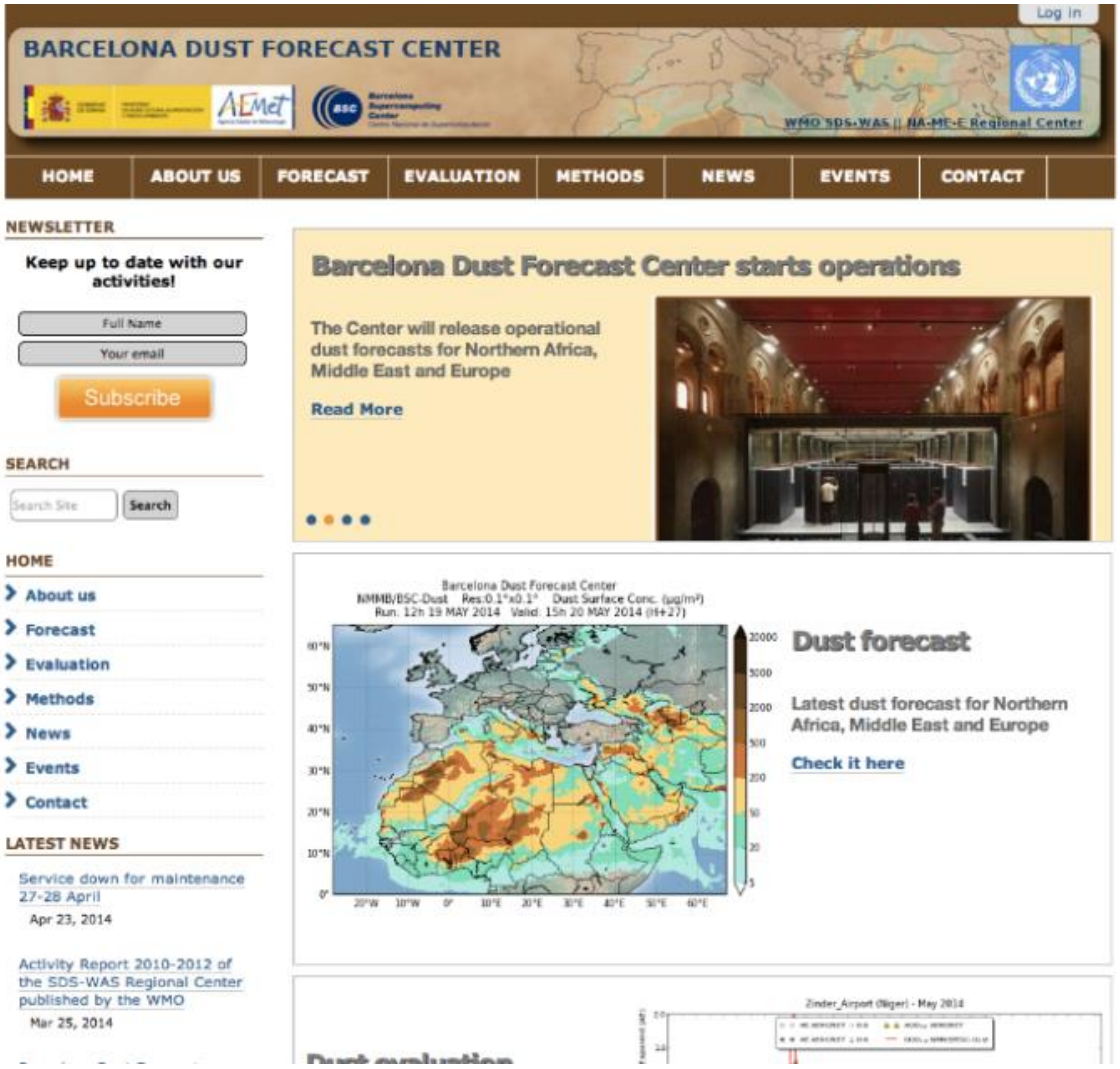
CALIOPE

Has been awarded the MYGEOSS prize for creating an app with air quality forecasts for European cities

ANDROID APP ON Google play

Available on the App Store

Mineral dust operational forecasts



Barcelona Dust Forecast Center

First specialized WMO Center for mineral dust prediction (since 2014)

World Meteorological Organization

Weather • Climate • Water

Seasonal hurricane predictions

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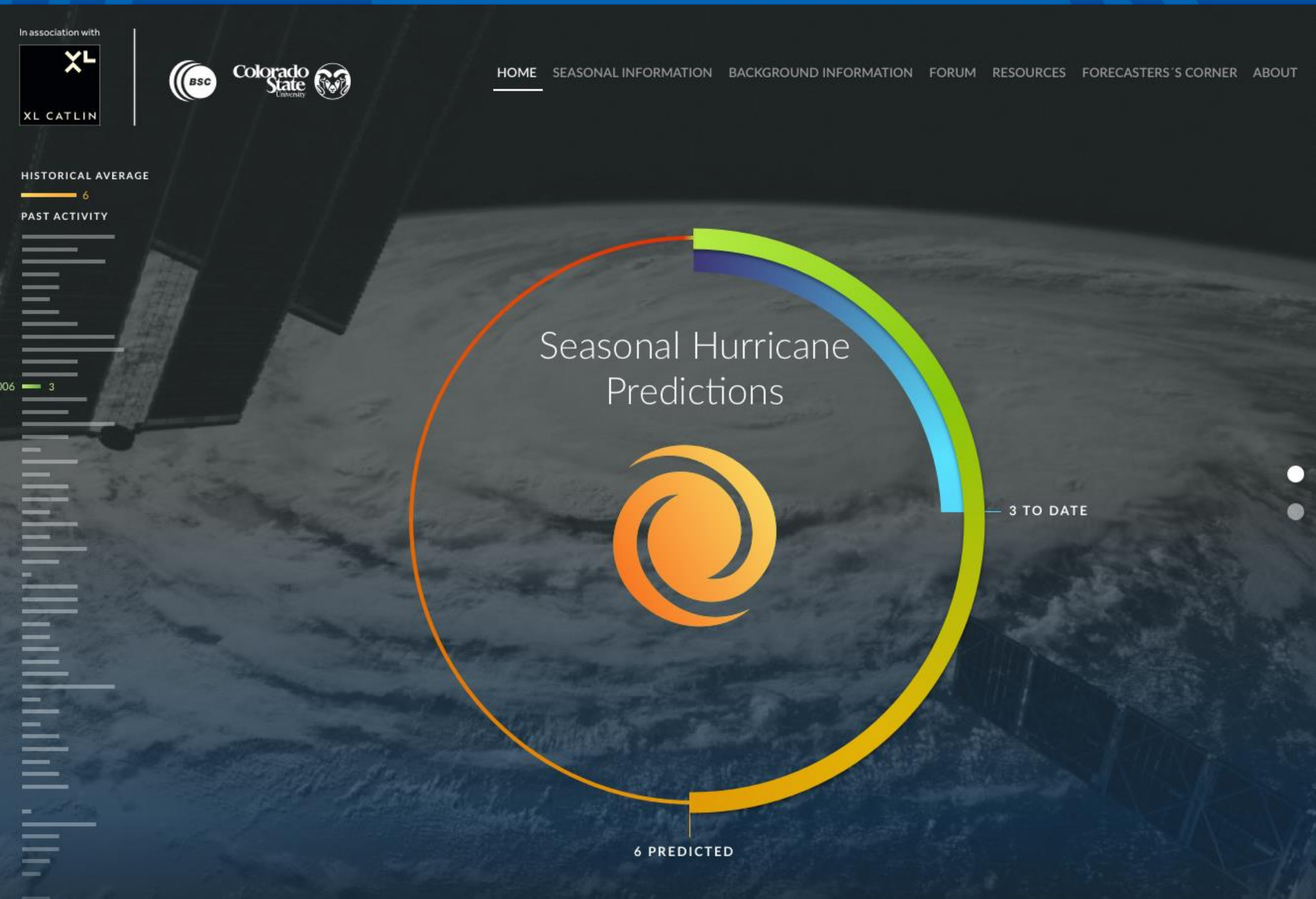

Seasonal wind speed predictions

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PROJECT **Ukko**

Developed as part of the
RESILIENCE PROTOTYPE
in the **EUPORIAS** project

SEASONAL WIND PREDICTIONS FOR THE ENERGY SECTOR

WHY?

Weather forecasts predict future wind conditions only in the range of weeks. Climate predictions look at big changes over years and decades. However, for energy traders, wind farm managers and many others, it would be crucial to understand wind conditions in the next few months.

LEARN MORE

HOW?

Based on sophisticated climate models, we are now able to provide new ways to forecast wind conditions in the next few months.

LEARN MORE

TRY IT OUT

Our interactive browser application allows you to explore the data. Which regions might experience unusual changes in wind activity in the coming months? Find out what our models can tell you.

www.project-ukko.net → GO

User-driven research

To perform this user-driven research two things are needed

HPC resources

- Access to computing (RES, PRACE)
- Optimisation of the community codes we develop

Data management solutions

- Data analysis tools with reduced data traffic
- Streaming
- Efficient storage
- Visualisation

Climate change is taking place

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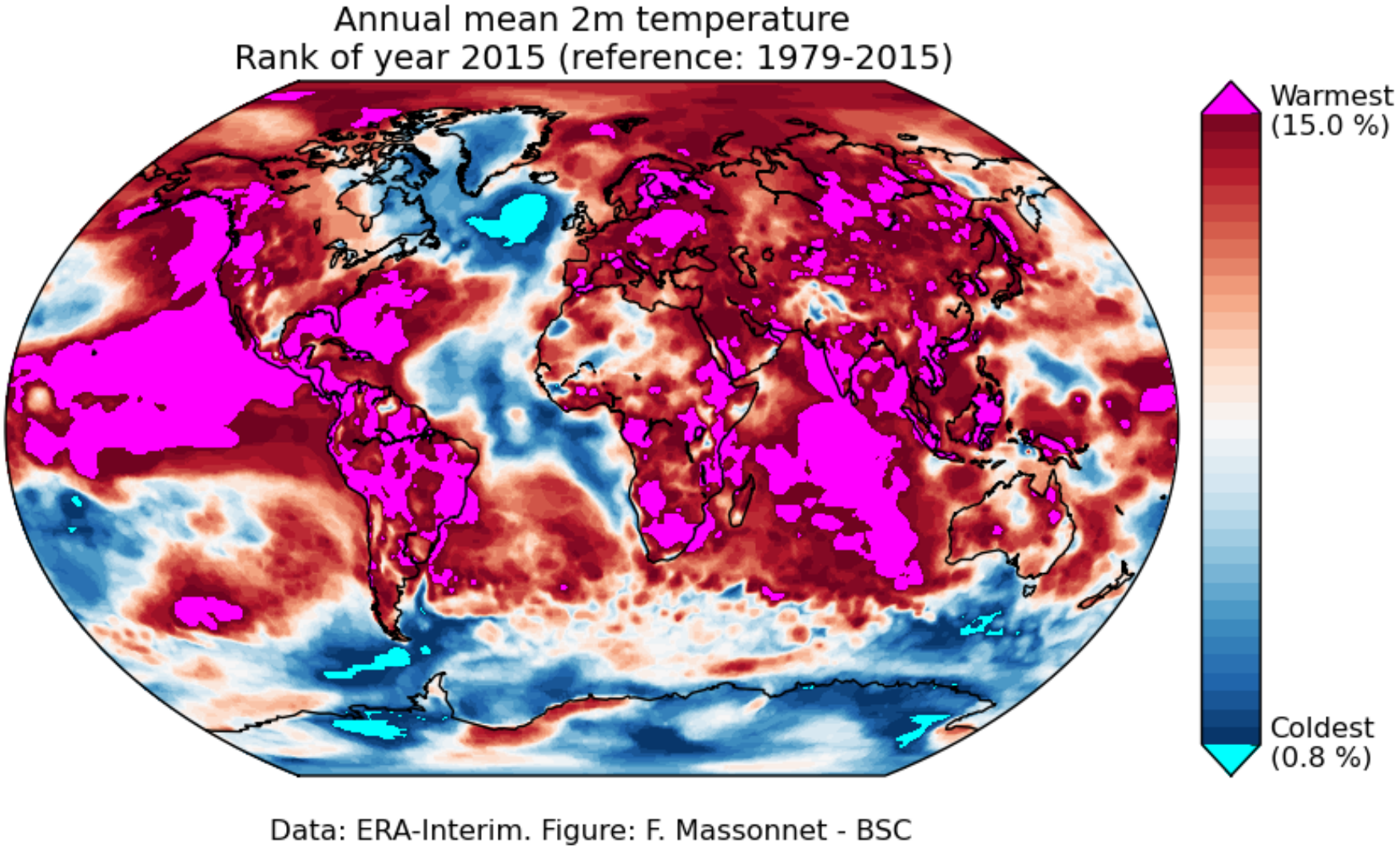
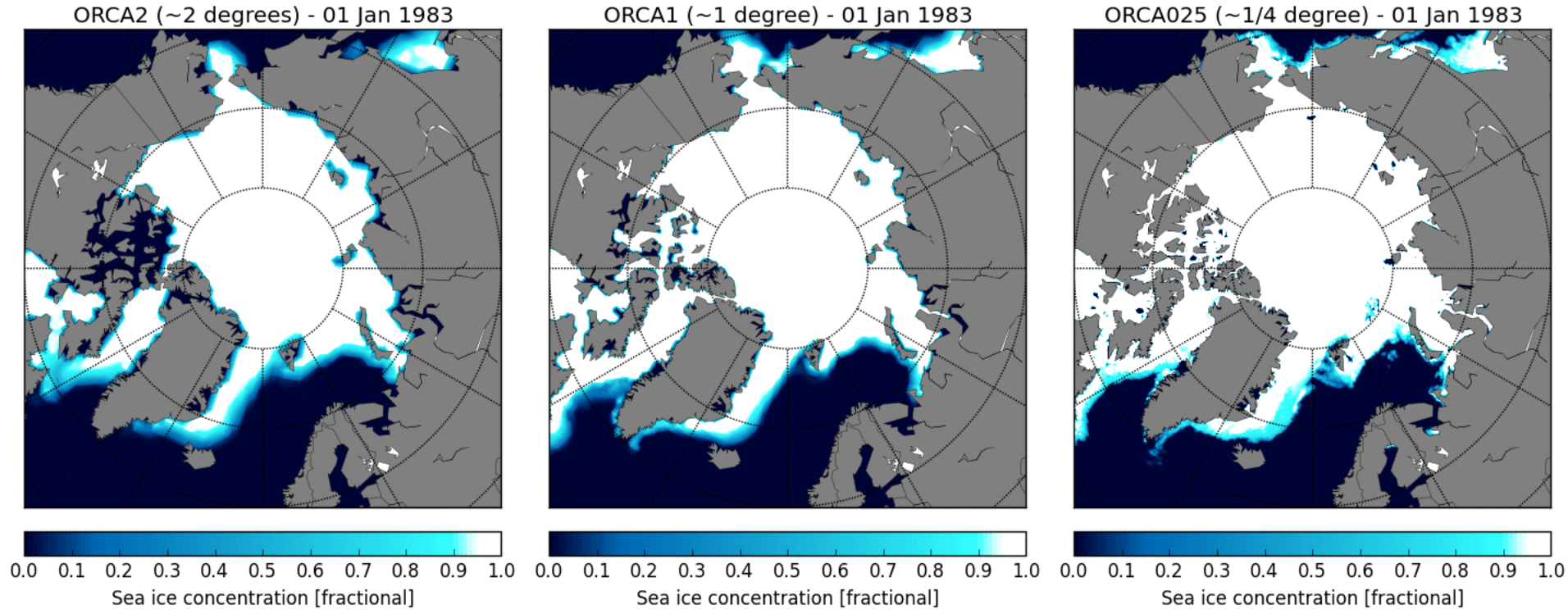
Rank of the 2015 annual mean temperature over the last 37 years from ERA Interim.



Climate modelling

Climate models are made of coupled binaries representing the atmosphere, ocean, sea ice, land surface, etc.

Arctic sea-ice simulation with the NEMO/LIM ocean/sea-ice model for three different spatial resolutions.



F. Massonnet (BSC)

Performing climate predictions

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Climate prediction is a large problem that requires running hundred of parallel jobs independently.

Computational efficiency and a flexible workflow manager are key elements.

High-resolution CMIP6 decadal prediction

5,500 simulated years

200 million CPU-hours, 1.4 PB

EC-Earth3 at Lindgren, PDC

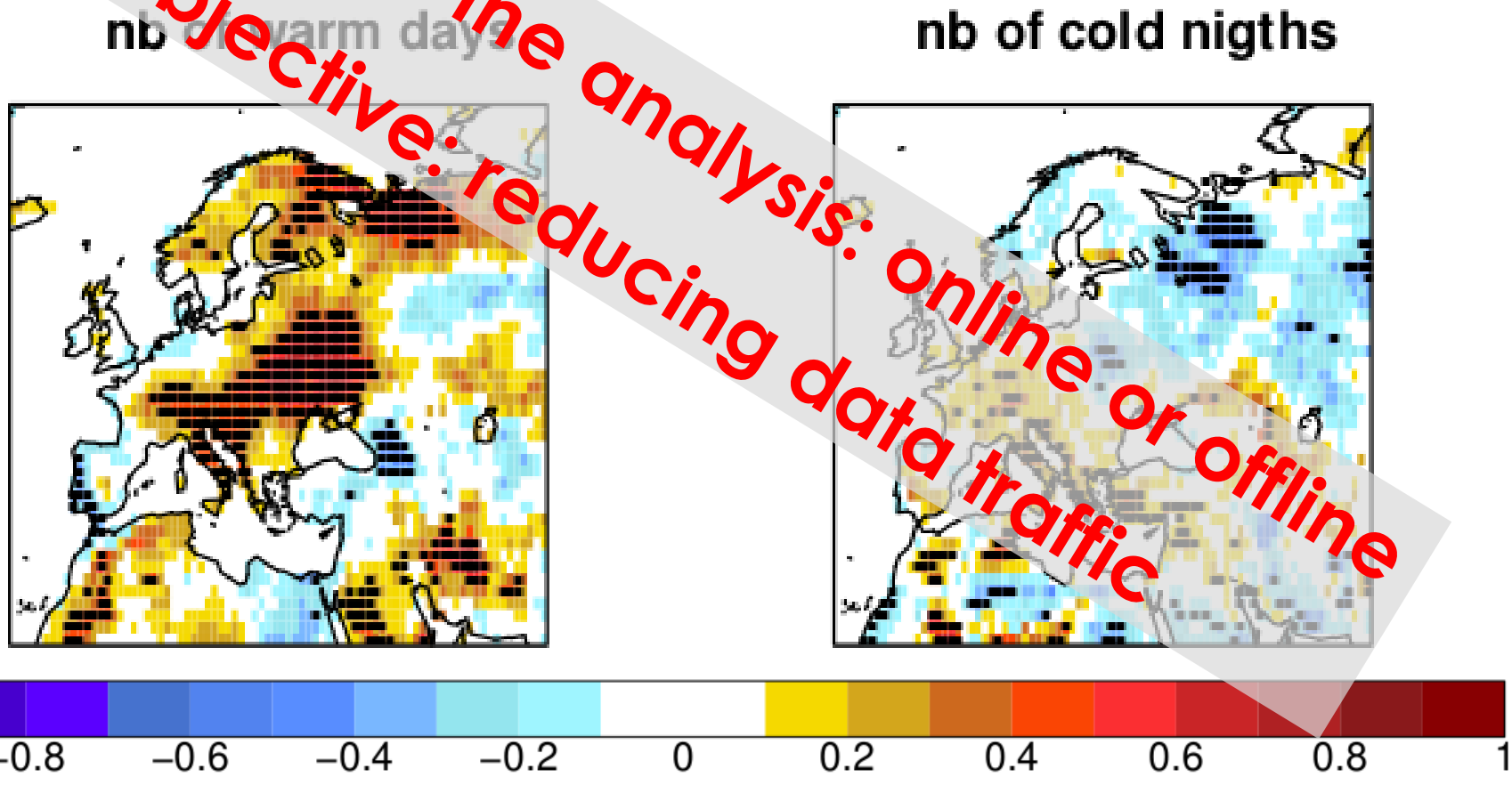
Number of Start Dates		1	5	10	10	20
Number of Members		1	5	5	10	10
Number of Independent Simulations		1	25	50	100	200
	Cores	144	3600	7200	14400	28800
Low Res	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	720	18000	36000	72000	144000
	Output Size (GB) / year	10,80	480	960	1920	3840
Med Res	Cores	360	9000	18000	36000	72000
	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	1800	45000	90000	180000	360000
	Output Size (GB) / year	19,20	5184	10368	20736	41472
High Res	Cores	1104	27600	55200	110400	220800
	Wall-clock Time (Hours) / year	40	40	40	40	40
	CPU Time (Hours) / year	44160	1104000	2208000	4416000	8832000
	Output Size (GB) / year	256,80	6420	12840	25680	51360

Predicting extremes

June-to-August near-surface temperature correlation difference between ensemble experiments with a climatological and realistic land-surface initialisation. Results for EC-Earth2.3 started in May over 1979-2010

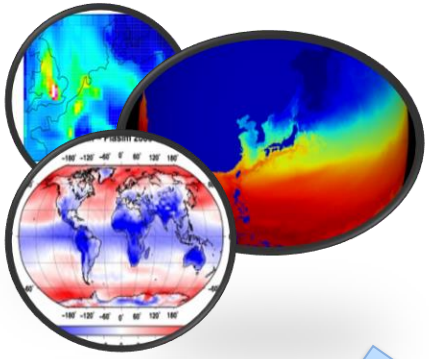
Two ways for the analysis: online or offline

Objective: reducing data traffic



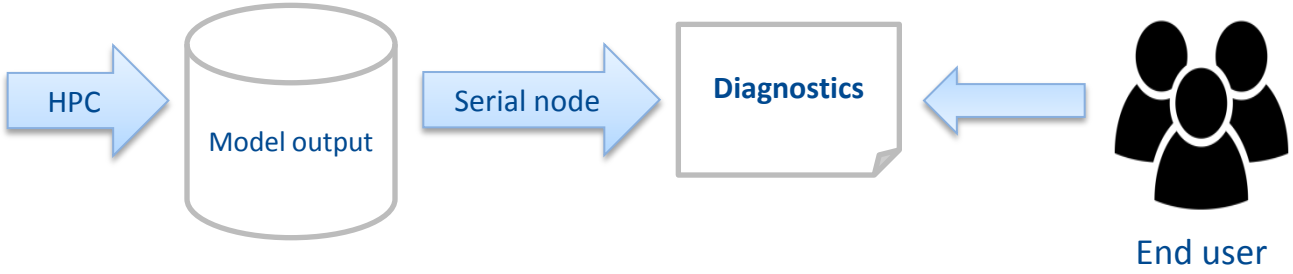
Prodhomme et al. (2015, Clim. Dyn.)

Online diagnostics

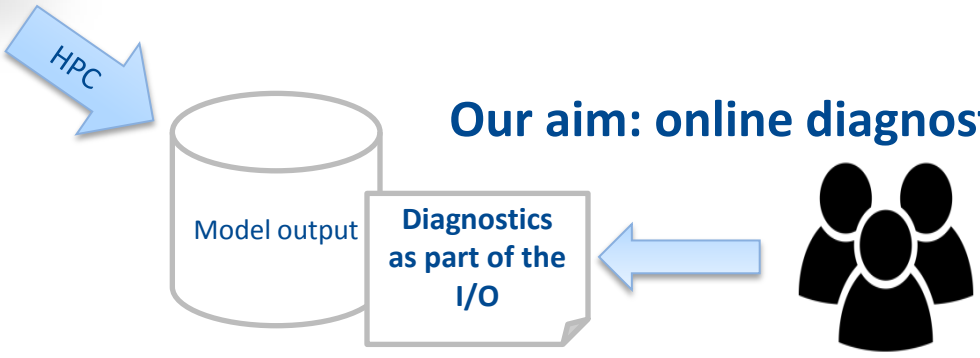


Climate model

Current approach: offline diagnostics



Our aim: online diagnostics



Analytics as a Service

- Diagnostics online during the run (either on compute node or elsewhere)
- Reduced data traffic and storage
- New diagnostics (data mining of extremes) possible
- The user gets the results faster → crucial to develop climate services (both public and private)

Some open questions

- **A new paradigm has come to stay: user-driven research**

- **Education**: in the era of open data, take advantage of the open education opportunities.
- **Heterogeneity**: link to and merge our data with communities with larger impact (urban, arts, social).
- **Technology**: make the most of a rapidly evolving technology (heterogeneous nodes, data software, mobile data capture, storage/compression, computing and storage outsourcing).
- **Industry engagement:** how can we solve the problem of involving more efficiently the private sector?